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Inside

Taking Time to Vent: Understanding Extraction and Exhaust

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Whether you are looking for a portable extractor for your home studio or to install or upgrade a hood in your institutional conservation laboratory, understanding the fundamentals of ventilation and airborne contaminant extraction is crucial to obtaining the most appropriate equipment, installing it in the most effective configuration, and understanding how to use it.

While ventilation and extraction systems for conservation laboratories should always be designed by a professional design team that includes both a mechanical engineer and industrial hygienist, a good understanding of general ventilation principles and exhaust options gives the conservator the tools needed to ask the right questions and provides the information required to get the best design for his or her needs.

The first step in safe ventilation practice is analyzing the work space and work flow to understand the processes and hazards involved. For conservators, variable exposure durations, frequency, and types of chemical or physical agents used in a complex array of tasks and situations complicates the assessment of risk for "normal" work situations. All of these factors are considerations in selecting equipment that can best manage the type of hazardous materials and processes intended for the space. *(See box 1: Understanding Exposure Limits)*

Unless the building heating, ventilating, and air conditioning (HVAC) system was specifically designed for a particular conservation laboratory, it will (most likely) only exhaust a small percentage of the air removed from any individual space. The remainder of the air is returned to the HVAC unit where it is filtered and conditioned, and it is then returned to the space. In this standard HVAC scenario, the ventilation system does not remove the contaminants, it simply re-distributes them.

Conservators may find themselves relying on pre-existing building ventilation systems, window fans, open doors and windows, ceiling fans, and air-conditioners to circulate and remove airborne contaminants without realizing these may not provide adequate ventilation, oftentimes using smell or sight to determine the effectiveness of contaminant removal.

In the absence of carefully designed ventilation and exhaust systems, chemical vapors can collect at either ceiling or floor level (depending on vapor density) and fine particulates can settle on surfaces or remain suspended in air, causing risk for long-term exposure and creating the potential for fire hazard. In addition, simple extraction of the hazard (e.g. removing or containing the contaminant with a portable "fume" extractor) does not have the same effect as a properly designed ventilation system, because by itself, local extraction is rarely, if ever, 100% effective. Also note that wearing a respirator will only protect the user and should not take the place of properly extracting or diluting a contaminant within an enclosed area. For more information on the use of a respirator, see "A Conservator's Guide to Respiratory Protection" at http://www.conservation-wiki.com/wiki/Health_%26_Safety:_A_Conservator%27s_Guide_to_Respiratory_Protection

Taking Time to Vent *continues on page 3*

Call for Papers Extended

AIC's 45th Annual Meeting, Chicago, IL, USA, May 28 - June 1, 2017, will have the theme "Treatment 2017: Innovation in Conservation and Collection Care."

Submit your abstracts online by **September 23, 2016**, at www.conservation-us.org/abstracts.

Box 1. UNDERSTANDING EXPOSURE LIMITS

Understanding safe exposure limits for the chemicals you are using is central to selecting and designing an appropriate ventilation system. At a minimum, you want to maintain exposure levels that meet federal exposure limits, but you should always strive to achieve the lowest possible exposure.

The following definitions refer to standards used to determine exposure limits:

- **Safety Data Sheet (SDS):** A document that contains information on the potential health effects of exposure to chemicals, or other potentially dangerous substances, and on safe working procedures when handling chemical products.
- **Exposure Values:** The two sets of time weighted standards for exposure values are Threshold Limit Value (TLV) and Permissible Exposure Limit (PEL). These values are set for individual chemicals, not mixtures, and for an average person. These standards cannot be used for highly irritating or immediate toxicity chemicals; short term exposure limits (STEL) and/or ceiling threshold limit values (cTLVs) should be used instead. Note that TLVs and PELs are not available for most chemicals; lack of exposure limits does not indicate that a chemical is safe, just that it may not have undergone review.
- **Time Weighted Average (TWA):** An average exposure of a hazardous material over an eight-hour period.
- **Threshold Limit Value (TLV):** A consensus standard developed by the American Conference of Governmental Industrial Hygienists (ACGIH) is a level to which it is believed a worker can be exposed day after day for a working lifetime without adverse effects. These values are generally more stringent than PELs because they are based on health factors and are revised regularly. However, they are only recommendations and have no legal standing. Values (if available) are now required to be included in Section 8 of the SDS or may be found in other published sources, including OSHA's website and for purchase through the ACGIH.
- **Permissible Exposure Limit (PEL):** The maximum amount or concentration of a chemical that a worker may be exposed to under Occupational Safety and Health Administration (OSHA) regulations. These standards are the law and can be enforced; however, they are based on old TLV values and do not take into consideration certain health effects. PELs can be found on the chemical's SDS or other published sources including OSHA's website.
- **Short Term Exposure Limits (STEL):** An average exposure of a hazardous material over a 15 minute period.
- **Ceiling Threshold Limit Value (cTLV):** Concentrations which should never, even momentarily, be exceeded.
- **Odor Threshold:** The lowest concentration of a certain odor compound that is perceivable by the human sense of smell.

Before considering the type of ventilation and extraction you need, assess:

- What chemicals are you using or what particulates are you producing? Are the contaminants lighter or heavier than air?
- Are there any explosion or fire hazards created? Will the ventilation system you want work for those hazards?
- Are you using other prudent health and safety practices to control exposure?
- Could you substitute hazardous materials with less toxic alternatives?
- Can you change your working habits, location, and/or procedures to reduce the exposure risks or contaminants produced?
- Will your ventilation/extraction protect you AND your coworkers, other building occupants, family members, and pets?

Going with the Flow: Basic Ventilation Theory

Basic airflow principles will help in designing your ventilation and extraction systems. In the setup of any ventilation system, consider the contaminated air and its movement (in, out and around) in relation to the user. The hazard should always be drawn away from the breathing zone and toward the exhaust; the conservator's head should be exposed to a continuous stream of clean air. Where you position your intake air and exhaust air with relation to the work projects is crucial; your hazardous materials work should always be conducted as close as possible to the exhaust inlet.

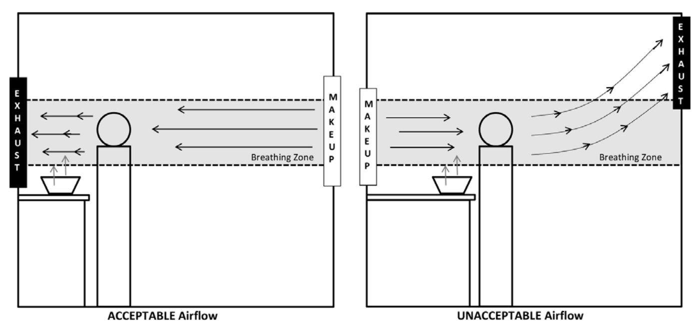

Figure 1: Acceptable and unacceptable direction of airflow when working with airborne contaminants. The quality of the air flow (both inlet/makeup and exhaust) is dependent on a variety of factors including placement of inlet and outlets, fans, and ductwork. Examples can be found in figure 2-1 of the *ACGIH Industrial Ventilation: A Manual of Recommended Practice.*

Think about not only how to get contaminated air out of the work area, but also where the air is being exhausted *to*. Always vent to the outside, but consider what is outside the exhaust vent in order to avoid recirculating contaminants back into your own or a neighbor's space.

- If the extracted air is not filtered or diluted, whoever or whatever is outside your exhaust is directly exposed to the hazards that you are removing from your workspace. This could include people walking outside on a sidewalk, your family in the yard, your neighbors, or your neighbors' pets. If your exhaust is adjacent to an intake, you could inadvertently be contaminating their space or your own.

- If you are exhausting out a window be aware of other operable, adjacent windows (both up, down, or sideways).
- If your contaminants are heavier than air, make sure the outlet is not located over or in an area that would let it pool, such as an exterior stairway down to basement, or a yard enclosed with a stone knee wall.
- If your contaminants are lighter than air locate the outlet high – above breathing zones.
- If you are using extremely toxic or corrosive materials such as carcinogens or strong acids, they should never be directly exhausted into the environment.

Exhausting air out means it must be coming in from somewhere; you will want to control where that air is coming from, because the air you are drawing into your studio will be contaminated with anything in the areas outside. Additionally, if you do not provide the appropriately sized air inlets, air will be drawn from uncontrolled locations and may counteract your efforts to create a clean breathing zone. *(See box 2: Positive vs. Negative Pressure)*

Air flow should be slow, smooth, and steady; any kind of air resistance (or friction) should be minimized; turbulence, whether from cross drafts or air moving through ventilation systems, should be eliminated to ensure the contaminated area is effectively removed without spreading the hazard or contaminant.

You can check the airflow in a room or the efficacy of your exhaust by following bubbles or a smoke trail using incense, matches, or other smoke-generating cartridges or tubes that can be purchased through laboratory supply stores. Check to see if the smoke is drawn into the studio or the rest of the building. You may want to observe air flow with your ventilation both on and off to make sure contaminants are not being drawn from your work space when you are not working.

Box 2. POSITIVE vs. NEGATIVE PRESSURE

Air will flow from areas of positive pressure to negative pressure. Differences in pressure may seem negligible and can be very difficult to measure; nevertheless, air will be drawn in or out of your space, carrying whatever contamination exists in the space and drawing it to or from other areas.

Controlling the quantity and quality of your intake and outtake sources assures clean and safe air resources. If your studio has negative pressure in comparison to the rest of the building, it will prevent your contaminated air from entering the adjacent spaces, but hazards or odors from adjacent spaces can migrate into your space. One way you may notice a pressure differential is that in a negative pressure space, outward-swinging doors become difficult to open, and inward-swinging doors may be difficult to close.

In certain scenarios, such as asbestos or mold abatement, you take advantage of pressure differentials in order to create a containment system (a room within a room where the inner room is negative and outer room is positive to the work area but neutral to surrounding space). This creates a flow of air from clean to dirty and also controls the source of makeup air.

Box 3. DILUTION vs. LOCAL EXHAUST VENTILATION

Dilution Ventilation

Dilution ventilation is created by bringing in clean air where it mixes with contaminated air before being exhausted out, thereby reducing the contaminants to a safe level. It is important to realize that you will always have some exposure to your hazard in using this method. Therefore, you must understand the exposure limits of the chemicals you are using (see *Understanding Exposure*), so that you can create a system that lowers concentrations to acceptable levels.

Dilution Ventilation, by itself, is not appropriate for particulates, aerosols or spraying, or any operation that produces surges of vapors or fumes. It should only be used for chemicals with low toxicity (those with TLVs ≥500ppm such as acetone or ethanol) or moderate toxicity (those with TLVs ≥100ppm and < 500 such as xylenes or mineral spirits). Dilution ventilation should only be used with very small amounts of chemicals with TLVs <100ppm (such as toluene and methylene chloride).

Local Exhaust Ventilation

Local exhaust ventilation involves placing extraction equipment at the source of the hazard to remove or collect the contaminants, so as to minimize the amount released into the work space. This method still relies on dilution to handle the smaller amounts of contaminate not directly captured (because of the air turbulence around the exhaust inlet). Local exhaust ventilation is required for moderate to high toxicity chemical vapors as well as for metal fume and particulate extraction.

Equipment type may need to be specific for the contaminant; state and federal regulations apply. Note that even if you are using equipment to draw away contaminants at the source, you still need clean make-up air; however, the amount of make-up air will (in general) be considerably less than with the dilution method alone.

Choosing the Right System

The two basic methods of ventilation are dilution ventilation and local exhaust ventilation. *(See box 3: Dilution vs. Local Exhaust Ventilation)*

Conservators (particularly those in home studios) are likely to rely on dilution ventilation because it is (usually) easily created in a studio space by using a combination of fans and open windows and/or doors, and requires little maintenance. Intake and exhaust should be on opposite walls to create appropriate airflow without interference from cross drafts. The amount of clean replacement air must equal the amount of contaminated air you are removing; otherwise you will not be able to control the quality or location of the additional replacement air. This also creates pressure differentials that may or may not be desirable *(see box 2: Positive vs Negative Pressure)*. Also note that the replacement air will likely need to be conditioned if you aim to maintain a specific temperature and/or relative humidity within your work space.

Fans may be the most economical way to ventilate your space using dilution ventilation, but creating adequate ventilation will require more careful consideration than just placing a fan in an open window, turning on a ceiling fan, or putting a standing fan next to your workbench. Residential AC systems should never be used to ventilate because they recirculate air and only bring in minimal amounts of fresh air; resulting in a buildup and/or redistribution (not reduction) of contaminated air. Additionally, the air outlets of most AC systems tend to disrupt the even air flow from clean to dirty that you are trying to create unless the AC system was specifically designed for lab use.

Fans are specified by air flow rate at a specific static pressure. The flow rate is the total volume of air moved per unit of time and is usually measured in cubic feet per minute (cfm). Static pressure is the force or air pressure the fan must overcome and is usually measured in inches of water (in. w.g.). For a specific fan, as static pressure rises, flow rate drops. When a fan does not list a static pressure, it is generally assumed to be for a non-ducted application and the air flow is rated at 0" w.g.

Axial flow or propeller fans (the type found in common household fans) efficiently move air with little energy and are the generally the best option for dilution ventilation in residential applications where existing windows or door openings will be used. These fans generally create 1000 cfm of air capacity for each foot of fan surface area (for example an 18" fan creates about 1800 cfm). Fan speed is measured in revolutions per minute (RPM), and every fan runs most efficiently at a certain speed.

The simplest way to determine the required air flow rate for fan use is to employ the "room air change" method. This method establishes the amount of air that is required to completely change out the room air volume in a predetermined period of time. This is usually measured in air changes per hour (AC/HR). For low hazards, such as toilet rooms, a minimum of 10 AC/HR is recommended and for moderate hazards, such as a home conservation studio, a minimum of 15-20 AC/HR is recommended. This approach should never be used for high hazards.

For example, imagine a conservator cleaning an object with 250 ml (~1/2 pint) of evaporated to xylene (TLV = 100ppm) for an hour in a 10' x 10' x 8' room. For this calculation you would need to obtain the recommended number of air exchanges per hour – let's use 15 AC/HR. The cfm required is the volume of the room (in cubic feet) multiplied by the number of air changes per hour divided by 60 (because you are converting units from hours to minutes). Based upon our 800 cubic foot room, this method indicates that 200 cfm would be a sufficient air exhaust volume. Note that this calculation did not take into consideration the amount of solvent being used or its toxicity; larger amounts of vapor or gas require more dilution and will be more concentrated in a smaller room. Always err on the side of providing more dilution.

A more effective method to determine the cfm required to create adequate dilution ventilation considers the quantity and toxicity of the chemicals and how you are using them. A dilution ventilation equation using the volume of air required to dilute the amount of solvent to its TLV, a subjective safety factor (K), and actual working time can then be used to calculate the generation rate or required cfm. A detailed explanation of this calculation can be found in the ACGIH Industrial Ventilation Manual (2.3.1). The 23rd Edition of the manual is available online (https://law.resource.org/pub/us/cfr/ibr/001/acgih.manual.1998.pdf) Using this calculation method for the xylene example, in a room with good airflow the fan should be sized at approximately 2500 cfm, or over 10 times what the room air change based calculation required. This reinforces one of the many reasons why conservation laboratory system design is usually best left to the engineers and hygienists.

Design and Selection of Your Local Extraction Systems

Local extraction systems are generally more complex and expensive than dilution, requiring higher initial investment in the purchase of the system, setup and installation, cleaning, inspection and maintenance.

One of the first decisions you may need to make is whether you need a ducted system in which contaminants are removed through a systems of ducts within the building structure and exhausted to the exterior, or a recirculation type system (also known as a "non-ducted" or ductless system). In a recirculation system, the contaminants are collected and run through a filter to "clean" the air, and then the air is returned back to the space.

Ducted extractors are required for most chemical and particle applications including applications requiring high volume chemical use, flammable or explosive hazards and moderate to high toxicity chemicals. Prices of the units will vary by size and features, but ducted systems tend to be more expensive than recirculation-type systems. Although a ducted hood can be 4x less expensive than a similar non-ducted hood, the additional costs of the associated building systems (ducts, air handlers, and other equipment) more than make up the difference. Some of the less obvious added costs include hiring engineers to design the systems and assess the implications of its use for the overall building. For ducted systems integrated into the building ventilation system, local codes and industry standards will dictate the minimum airflow rates and acceptable locations for the exhaust outlet and air intake.

It may require several months to install a ducted system, particularly if the building ductwork is not already in place. Because of their static position, ducted hoods allow the use of additional fixtures within and around them such as airflow monitors, electrical outlets, compressed air, laboratory gas, vacuum and cold water fixtures, chemical storage, cabinets, and work surfaces. Once they are installed, they may make future renovations more difficult and costly if they need to be moved. Fixed positions and limited sizes of full enclosure, canopy or slot hoods, may also limit object treatments. A snorkel or elephant trunk, a small canopy-type hood connected to a flexible duct, allows for repositioning as needed, and is very popular with conservators. For local exhaust systems, these flexible ducts are attached to a single point on the wall or ceiling and evacuate air through a building ventilation system.

The wide range of non-ducted equipment from hoods to small portable units creates a large number of options at various price points. The major additional cost for ductless extractors is the price of filters, which can range significantly, and how often they need to be replaced is dependent on how heavily they are used. There may be additional costs for shipping and disposal of the filters but the overall energy costs will be lower. Installation times are much shorter than for ducted systems because they do not require major building alterations to accommodate ductwork. Also, they can easily be moved for future renovations or project needs.

Non-ducted exhaust systems should not be used for large amounts (> 500ml) of moderate to high toxicity chemicals or for tasks that produce heat (welding). Some chemicals cannot be safely filtered or aren't filtered effectively enough. For example, methanol is not effectively collected by a filter.

Components of Local Exhaust Ventilation

There are four components of any local exhaust ventilation: hood, ducts, fan and air filters—all systems should be well-planned and selected with care, (whether a portable/moveable extractor or a ducted hood) preferably in consultation with an appropriate HVAC specialist, engineer, and/or industrial hygienist and especially if the systems will involve creating or modifying building ventilation systems or structures.

While there are numerous hood, fan, duct, and filter options that can be chosen for specific needs and to best minimize exposure, it is important to note that no local exhaust system is 100% effective due to local air currents created through movement around the hood opening or trunk/snorkel inlet. Fume hoods can be considered 99% effective, and trunks/snorkels no more than 90% effective. Glove boxes and filtered containment enclosures are the only forms of local exhaust that completely ensure is no exposure and are used when working with extremely hazardous chemicals and for asbestos mitigation.

HOODS:

The hood is the part of your system that captures the contaminant. Types includes complete enclosures (like fume hoods with a sash), canopy, slot, plain opening, and dust collecting hoods. When selecting hood type, you will consider the toxicity of your hazard, the type of contaminant (dust, gas, vapor, etc.) and how it is released. When functioning and used properly, hoods provide excellent protection, isolating and extracting the hazard. However, their size and shape can limit the kinds of object being treated as well as the movement and access during treatment.

Your hood should provide a capture or face velocity measured in feet per minute (fpm) that draws your contaminant in completely in a range from about 50 to 2000 fpm, depending on your task and the movement of air and contaminant. For simple evaporation, minimum fpm should be 50-100. For spray booths and other low velocity contaminants released into moderately still air (such as welding), capture velocity should be in the 100-200 range. *(See also box 4: Spray Booths: A Special Situation)* For hazards that are quickly released into rapidly moving air (such as mixing of dusts and using kilns and furnaces that produce fumes), recommended minimums are 200-500 fpm. For high velocity contaminants like woodworking, grinding, abrasive blasting, 500-2000 fpm is required (ACGIH 1998, Table 3-1). Fpm can be measured with a meter, either a hand held unit, or one built into the hood frame. Portable meters are available from lab safety suppliers at a relatively low cost.

When working with local exhaust, the hazard should be as close as possible to, or enclosed within the hood, because contaminant capture efficiency is inversely proportional to the square of the distance from the hood. Hoods have a stronger draw towards that back, so working further back in the hood is recommended, although not always practical in conservation practice.

Box 4. SPRAY BOOTHS: A SPECIAL SITUATION

A spray booth is a power-ventilated structure provided to confine and limit the escape of vapors and aerosols, such as mists/combustible residue, dust, smoke and fumes. Spray booths have recommended airflow rates that vary with the toxicity of the solvents used and task employed. Spray booths have very specific regulations for their construction and use. In some places (such as New York City) they must be registered and meet specific codes for noise emission, electrical sources in and around the booth, and ventilation specifications.

Because spray booths have the potential to combust there are strict federal standards (see OSHA Standard 1910.107 and NFPA 33 Spray Applications). Regulations include the placement of sprinkler heads, clearance, ignition sources in and around the booth, what solvents can be used, and provisions for filters and fans. In addition, there are various types of fans for use in spray booths that are constructed to minimize the chances creating sparks. Type A "blower fans" ensure that any materials in contact with the air stream are spark resistant; Type B have nonferrous wheels and rubbing rings; and Type C have nonferrous plates.

For trunks/snorkels to function properly, you should be concerned with the capture velocity (V) on the surface of the object, not just the face velocity at the opening of the hood (for solvent vapors and gases this should be around 100 fpm at the object surface). Capture velocity (fpm) and exhaust volume (cfm, also called air capacity or air quantity) are related through a mathematical equation that includes the distance from the source to the size of the hood opening. This calculation demonstrates that a trunk/snorkel (because of its restricted hood size) has to be very close to the contaminant to be effective. When you cannot get close with a snorkel, you should probably be looking at another type of hood, something with a larger capture area like a canopy hood (for contaminates lighter than air) or a downdraft table (for contaminates heavier than air). Multiple ducts may be another alternative; for example, one could be placed adjacent to the mouth of your solvent container and a second could be positioned as close as safely possible to area of the object you are treating. The shape of the opening of the trunk has an effect on the capture efficiency.

DUCTS:

Ducts serve to carry the contaminants away once they have been captured by the hood. There are several considerations for duct construction, most of which serve to reduce the system's resistance and increase efficiency. The main considerations are:

- Material: Choose a material that is compatible with the types of hazards you are using. Usually this is galvanized or stainless steel. However, highly corrosive materials may require more expensive plastic ducts.
- Shape: Round ductwork is preferable to reduce resistance. Surfaces should be smooth and clean. Kinks, crimps or turns increase the resistance as well as the possibility of contaminants becoming trapped in the system.
- Length: Reducing the length of ductwork both from the

capture and the exhaust reduces cost and increases efficiency of the system.
- Size: A duct size that will exhaust air from the hood at a specific, optimum duct velocity required for particular contaminants. This is at least 3500 for particulates. Any velocity is sufficient for vapors, gases and smokes, but (1200 to 2500 fpm is the most economically efficient) (ACGIH 1998, Table 3-2). Duct work comes in a variety of diameters and thickness (gauge). The smaller the duct size, the greater the velocity and resistance (which increases the static pressure needed from the fan).
- Flexible Ducts: These are spiral in shape and made from fabric (cotton or neoprene), plastic, or metal (aluminum or stainless). Metal should be used for high temperatures, corrosive materials, solvents and dust.

FANS:

Fan selection is incredibly complex. Among other variables, ventilation experts will consider:
- the volume of air to be removed (cfm)
- static pressure (the amount of resistance in the system to overcome)
- efficiency
- explosiveness of materials
- space
- noise
- temperature

Local exhaust systems require centrifugal fans (where the air flow is discharged perpendicular to the fan's blades) and not axial propeller fans (where air flows straight through the fan), as discussed in the section on dilution ventilation describing axial fans. Fans should be installed at the discharge end of the ductwork to keep the contaminants contained in the ductwork and downstream from air filters to prevent damage to the fan parts.

AIR CLEANING DEVICES AND FILTERS

Air cleaners and filters are required for several reasons: health and safety concerns, environmental regulations, and removing particulates. Always check with industry standard and local regulations before releasing or disposing of any contaminate.

Filters may be used on exhaust air extractors to prevent hazards from being released to the environment, on recirculation-type extraction systems to protect space occupants, or on makeup air systems to protect the objects themselves from external contaminants.

Chemical Filters:

Fume extraction filter systems are carbon based, and the contaminant is collected by the filter before the air is recirculated or released outside. Self-contained units that rely only on filters to clean the air and then introduce the air back into the work area (oftentimes called portable fume extractors) create a real risk to health and safety since there is no predictable way to determine when the filter is no longer able to collect contaminants *(see box 5: Portable Fume*

Box 5. PORTABLE FUME EXTRACTORS

While filter-based fume extractors are discouraged by health and safety professionals, these may be the only option for conservators working in studios that are situated inside homes, in rooms without windows, or where the building structure cannot be altered. Because of the limitations of filter-based systems, the conservator should combine the fume extraction system with a dilution exhaust system and locate the outlet of the portable unit as close to the exhaust point as possible.

The Health & Safety Committee is currently working on a guide to help conservators research, purchase, and safely use portable fume extractors based on experiences of both conservators and health and safety professionals. If you would like to contribute to the guide, please complete the following survey by October 15:

https://www.surveymonkey.com/r/5GWBS6P

Extractors). The risks of recirculating contaminants back into the work space is particularly high in situations where there is irregular use of a variety of chemicals, or with multiple users (common in conservation practice). Furthermore, filters are specifically absorbent for particular chemicals, so it is important to check with the manufacturer to determine whether the filter type is compatible with the chemicals you will be using. Filters should be changed on a regular schedule according to manufacturer recommendations, and the rate of change is dependent on the type, temperature and volume of chemical used, filter capacity, evaporation rate, and the duration of use. Note that when filters are saturated, contaminated air is released back into the work environment without any warning to the occupants.

Particulate Filters:

Particulate filters are easily maintained, relatively affordable, and it is reasonably simple to determine when they need to be changed. These filters can be easily monitored for filter loading using a differential pressure gauge, and when selecting a portable unit for particulate filtering, choose one that comes with an integral pressure gauge. Health concerns for particulate exposure can vary from irritation, allergic response, chronic disease, poisoning, to death; particles less than 10 microns are considered respirable, meaning they penetrate to the gas exchange region of the lung as compared to inhalable particles, which includes anything that can enter and settle in the respiratory tract. High efficiency particulate air (HEPA) filters should always be used for particulates with which conservators come in contact. HEPA filters will capture particles larger than 0.3 microns, while ULPA (ultra-low particulate air) filters will filter out particles larger than 0.12 microns in size. Nano-particles or ultra-fine particles (defined as particles between 0.001 and 0.1 microns) are too small for capture by ULPA filters, and these extremely small particles can cross cell membranes to enter the blood stream and various organs. Conservators may be exposed to these particles when using certain pigments (e.g., titanium dioxide or zinc oxide) or in 3D printing applications. It is important to remember that even ULPA filters DO NOT capture 100% of the particles.

Types of Airborne Contaminants

Contaminant		Size** (microns)
Gases*	A state of matter in which the material has very low density and viscosity. Gases expand and contract greatly in response to changes in temperature and pressure, easily diffuse into other gases, and readily and uniformly distribute throughout any container.	N/A
Vapors*	The gaseous form of substances that are normally in the solid or liquid state (at room temperature and pressure). The vapor can be changed back to the solid or liquid state either by increasing the pressure or decreasing the temperature alone. Vapors also diffuse. Evaporation is the process by which a liquid is changed to the vapor state and mixed with the surrounding air. Solvents with low boiling points volatilize readily.	N/A
Fumes*	Airborne particulate formed by the condensation of solid particles from the gaseous state. Usually, fumes are generated after initial volatilization from a combustion process, or from a melting process (such as metal fume emitted during welding).	<1
Mists*	Suspended liquid droplets generated by condensation from the gaseous state to the liquid state or by breaking up a liquid into a dispersed state, such as by splashing, foaming, or atomizing. Formed when a finely divided liquid is suspended in air.	1-100
Aerosols	Particles (solid or liquid) that remain suspended in air for a period of time. Aerosols include mists, smokes, fumes, and dusts.	<0.01-100
Dusts*	Solid particles generated by handling, crushing, grinding, rapid impact, detonation, and decrepitation of organic or inorganic materials, such as rock, ore, metal, coal, wood, and grain. Dusts do not tend to flocculate, except under electrostatic forces; they do not diffuse in air but settle under the influence of gravity.	0.01-100
	Fabric Lint	10-100+
	Mold	10-100
	Abrasive Cleaning	0.3-30
	Colloidal Silica	0.01-0.1
	Ceramic frit	1-30
	Pigments	0.1-5
	Wood Dusts	0.1-100
	Asbestos	0.5-30
	Metal Dusts (grinding, buffing)	0.5-100
	Metal Fume (welding, soldering)	0.01-0.5
Smokes	A complex mixture of different gases and particles, which results from the burning of various materials. Smoke is the result of incomplete combustion, which produces tiny particles of carbon in the air. When deposited, these particulates are identified as soot.	0.01-1

**Fundamentals of Industrial Hygiene*, by Barbara A. Plog et al., 2012, published by the National Safety Council.

**Clark, et. al 1984

Summary

This guide is intended to introduce conservators to the basic principles and concerns involved in creating proper ventilation within their work place. There are numerous technical resources that cover this topic in greater detail, which should be consulted in conjunction with technical experts. An HVAC or mechanical engineer can help you determine the best equipment based on your industry standards, building codes and environmental regulations. An industrial hygienist can help you determine the best equipment and work practices for your unique exposure, and fellow conservators can help recommend features that may be unique to conservation practice.

Finally, protecting yourself doesn't end with the selection or installation of your extraction and ventilation systems; without proper protocols, you may not know if your system is malfunctioning until after exposure has occurred. Inspection, maintenance, and training on the proper use of these systems are essential to maintain health and safety for yourself and the individuals around you.

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Have a question about health and safety in your conservation work?

Email HealthandSafety@conservation-us.org.

Definitions Used in this Article:

- **Air Capacity, Air Quantity or Exhaust Volume (cfm)**: The volume of moving air per unit time
- **Air Velocity (fpm):** The speed of air in feet per minute. Varies throughout a ventilation stem depending primarily on the shape through which it passes.
- **Capture Velocity:** The air velocity required to force the contaminated air into the hood and away from the source of the contamination
- **Duct Velocity:** The average air velocity in the ducts to move. Static pressure is either positive or negative in relation to atmospheric pressure.
- **Face Velocity:** The average air velocity across the opening of a local exhaust hood or extractor
- **Make-up or Replacement Air:** Air brought into the workspace to replace the aired exhausted by the ventilation system
- **Static Pressure:** The potential pressure exerted in all directions that must be overcome for air
- **Transport Velocity or Conveying Velocity:** The velocity in the ducts required to keep solid particles moving in the airstream. Minimum velocities vary based upon the specific contaminants.
- **Velocity Pressure:** Force exerted by air that is moving. It is exerted in the direction of flow and is always positive. Velocity pressure in the ducts of a ventilation system is used to compute pressure loss of air entering a hood.

(Source, Clark, et. al. 1984)

AIC News

Internal Advisory Committee to Meet Nov. 11

The 2016 meeting of the Internal Advisory Group (IAG) will take place on Friday, November 11, in Washington, DC. The Kimpton Mason & Rook Hotel, located at 1430 Rhode Island Avenue, NW, is serving as the host hotel. If you have comments or concerns you'd like addressed at the meeting, please contact your specialty group chair, or relevant network or committee chair, before November 11, 2016.

AIC Board Elections

The AIC Nominating Committee encourages members to submit nominations for qualified individuals as candidates for election to the following positions:

- President
- Vice President
- Director, Professional Education
- Director, Specialty Groups

The Nominating Committee must receive completed nominations by February 28, 2017, three months prior to the May Member Business Meeting at the Annual Meeting in Chicago, IL. The AIC Bylaws require that candidates for president and vice president positions be Fellows and candidates for director positions be Fellows or Professional Associates. The nominees for all positions must be members in good standing of AIC and should have prior experience with the functioning of the organization through service on committees, task forces, specialty groups, or in other capacities.

Committee members will be pleased to discuss any aspect of the nominating and election process with potential candidates and anyone interested in nominating candidates. Please contact Victoria Montana Ryan (acs@artcareservices.com), Jodie Utter (jodieu@cartermuseum.org), or Beverly Perkins (beverlyp@centerofthewest.org).

Nominating Committee

The Nominating Committee is seeking nominations of qualified members as candidates for the Nominating Committee election. The committee, composed of three members each serving a three-year term, has one vacant position each year. The 2017 candidate can be either a Professional Associate or Fellow member of AIC. With approval of the revisions to the AIC Bylaws on April 30, 2015, nominations are made to the chair of the Nominating Committee and must be received February 28, 2017, three months prior to the May Member Business Meeting in Chicago, IL. An electronic vote will be held in conjunction with the votes held for Board member positions.

—AIC Nominating Committee, Victoria Montana Ryan (acs@artcareservices.com), Jodie Utter (jodieu@cartermuseum.org), Beverly Perkins (beverlyp@centerofthewest.org)